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ABSTRACT

Computer assisted learning (CAL) is an old technology which has generated much new interest. Computers can: reduce data to a directly comprehensible form; reduce administration; communicate worldwide and exchange, store, and retrieve data; and teach. The computer's limitation is in its dependence on the user's ability and perceptive nature. Teachers can either ignore CAL and computing or become involved with them. CAL is appropriate: when it is difficult or impossible to teach the use of a topic in another way; in remedial tutoring; and in replacing practical experiments with simulations. Using computers to find information, manage instruction, and for electronic mail and networking can also assist learning. CAL should make maximum use of color, sound, and movement; be visually and intellectually stimulating; involve the user; and supply plenty of criticism, help, and advice. Because information is presently lacking concerning the instructional effectiveness of good CAL, formative evaluation should be emphasized and results of such assessments should be publicized through educational journals and conferences. (LMM)

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THE NATURE OF COMPUTER ASSISTED LEARNING

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THE NATURE OF CAL

Computer Assisted Learning, (CAL), is not a new idea; it has been with us for thirty years. However, through a combination of cheap and versatile equipment, popular imagination and government funding in the United Kingdom, a great deal of new interest has been generated in the Primary and Secondary sectors of education. What most forget is that CAL is an educational technology, which should take its place alongside all the others.

Educational Life Cycles

[1] What happens when a new educational technology arises, or an older one (like CAL) develops a new lease of life? Much the same sort of thing in all cases; there is a common Life Cycle. A prototype idea is devised and is publicized through the journals and conference circuits. If the idea possesses any merit at all, and especially if it looks as though funds may be available for its development, then a bandwagon starts to roll. Transitory reputations are made, groups of zealots arise and missionaries spread the word to the heathen.

At about the same time, the defects inherent in the prototype start to show themselves; no prototype is perfect. Knowledge or experience of these spread disillusion, and prejudice the uncommitted. Many of the converted recant of their heresies, and often become condemnatory on the slightest of evidence. Those who see their transitory reputations being tarnished rapidly sidestep on to the next bandwagon. Work on the prototype is abandoned except for a few devotees working away in obscurity. These latter eventually produce a working system. When they attempt to publicize this they are disregarded since "everyone knows" that the idea has been discredited long ago.

This has happened once already with CAL, but now the general purpose microcomputer has started the bandwagon rolling again. Whether CAL will be disregarded again is problematic, but the pervasive nature of the cheap microcomputer and its ever expanding capabilities makes it unlikely. Facile truisms about the so-called "Microchip revolution" do have a basis in the real world, and it is from the real world that the stimulus for use of computers in education comes, unlike most other educational innovations.

Purposes and Limitations

[2]It is worthwhile reminding ourselves what computers can do, both in general and in education. Simply stated, four things:

1. Reduce data to a directly comprehensible form.

2. Reduce administration, or rather, to be more realistic, allow one to cope with most of its increase.

3. Communicate worldwide, exchange, store and retrieve data.

4. Last but not least, TEACH.

None of these tasks are beyond comprehension, none are difficult and none can be efficiently or completely done without sophisticated computer assistance; except of course, the last. As far as CAL is concerned, the limitation upon its use is where it ought to be for any educational technology, ie, the wit, ability and perceptive nature of its user. [3] Financial limitations still exist of course, but cheap computers are now much the same price as overhead projectors, slide projectors or a fortnight's pay for a vice principal. Operational considerations are minor, compared to what they used to be when a large mainframe computer was the only resource for CAL. Anyone can use a microcomputer within a few hours of acquiring it - ask any ten

year old just after Christmas.

Alternatives for Teachers

There are only two alternatives [4] - ignore CAL and computing in the hope that it will all go away, or get involved in it. From my viewpoint, as a writer and user of CAL for only a few years, the choice between the two is now obvious. Get involved! The nature of the involvement, however, is unlike involvement with any other educational technology. Ask anyone who has bought a computer for the children, or for themselves. The message is simple; involvement very often means TOTAL involvement for varying periods of time of the order of months. Computers are very absorbing and can easily become an end in themselves. Raw fingertips at three in the morning are not unknown. Nor is a regrettably common lack of discernment about software. Most educational software currently available seems to be based upon behaviourist principles of "Drill and Practice, though the position in the United Kingdom has been improving somewhat over the last year or so. There is one golden rule to remember when either assessing or writing software (or anything else for that matter), devised by the science fiction author Theodore Sturgeon, which states: [5]

Ninety percent of EVERYTHING is rubbish.

Whilst it would be foolish to condemn software sight unseen, much of it advertised as "Educational" seems to be based on "Drill and Practice" methods beloved of the operant conditioners. Teaching something by behaviourist methods undoubtedly results in learning when multiple choice is used for assessment. Learning is less apparent when tested by methods which emphasise understanding or evaluation of what has been "learnt". This implies that the teacher's role becomes one of encouraging understanding and cognitive development, rather than rote learning of facts. behaviourist CAL is, unfortunately, very easy to program. It is much more difficult to write programs which encourage the higher cognitive abilities. In turn, this implies that CAL should only be used in circumstances which are appropriate for it.

Appropriate Circumstances for the Use of CAL

The first set of circumstances ought to be self-evident; when it is difficult or outright impossible to teach the topic in any other way. [6] As a biologist, these are some which have successfully been used to my knowledge. You can no doubt imagine similar circumstances within your own disciplines. Most of the available programs are simulations of one sort or another, in which the user is encouraged to input parameters to an algorithm

and view the results. A process of gradual optimization follows, via inductive reasoning, and the user comes to understand the model. Most models of this kind do not give any tutorial assistence and are thus wasteful of time, though once learnt, the knowledge remains for a long period.

[7] Remedial tuition is the second set of circumstances. This can be very boring and repetitive for both teacher and pupil. Motivation to learn is discouraged precisely when it ought to be stimulated. If a flexible tutorial program is written instead, the pupils can use it whenever they wish, as often as they wish and without much contact with the teacher. This sort of CAL is best written in an author language with good text recognition facilities such as "STAF2" for mainframe and CP/M machines, Acornsoft's "Microtext" for the BBC machine or Super PILOT on Apple or other computers. Easier programming plus much more flexible and interesting tutorial or adventure type programs.

[8] Practical experiments can be replaced by computer simulations. Provided that the object of the experiment is not to inculcate practical skills, then this is appropriate. Often, experiments require a lot of tedious and repetitious calculations of doubtful educational relevance. Also, computer mediated control of laboratory equipment can be used, in both directions. First to log data, analyse them and present the results, and second, to reproduce data from computer memory to run machinery

or robots.

There are one or two other areas where the use of computers to assist learning would not be regarded as CAL by purists. I would agree with them in respect of their nature, but not in respect of their purpose, since any use of computers which either frees a teacher's time or makes the teaching more efficient, or both, is to my mind, CAL.

The first of these is what information technology is all about, namely, finding the information. [9] It is now possible to access information stores and databases almost anywhere in the world from the keyboard of most computers. Prestel in the UK and equivalent systems elsewhere are one example. Another is a system like Dialog or ERIC, which many teachers and lecturers use to scan the research literature. Why spend three weeks looking through a cubic metre of abstracting journals when half an hour online to a computer in California at three dollars a minute will search them for you? Simpler and much more cost effective. Children can learn from constructing simple versions of these, mostly using declarative languages such as Prolog, as can anyone trying to learn how to use a commercially available database software system.

A second impure circumstance is Computer Managed Learning, usually found under the acronyms CML or CAMOL. These systems are meant to make the administration of learning easier. However,

what usually happens is that the software system has been written for the benefit of the administrator rather than the teacher. Anyone familiar with B/TEC courses will know what I mean. However, the concept is right even if its execution in practice is corrupted. There's no reason why more sensible programs cannot be written by the teachers themselves, and it is heartening to know that this is beginning to happen.

A third circumstance, derived from both of the above, is the use of electronic mail and networking; both currently very fashionable. It is conceivable to run distance learning through database networks like Prestel or in LAN within a smaller area. The Council for Educational Technology, amongst others, have been investigating this sort of approach for some time, as has the Open University in Britain. Given a sufficiently dense network to which the majority of any population has access for little if any cash, this part of the educational information explosion will soon go exponential.

Characteristics of CAL

If the foregoing were the appropriate circumstances for the use of CAL, then what sort of characteristics ought the CAL itself possess? This may be approached from two points of view; that of the teacher and that of the users of the CAL programs.

I was critical earlier about currently available educational software because of its "programmed learning" nature. Most often this type of programming arises for two reasons; first that it is easiest to program and second because much educational software has been written by professional programmers. [10] Thus these differences. A professional programmer will write efficient programs which run quickly and produce the expected results with the minimum expenditure of processing power or other computer resources. That is how professional programmers are trained to do so. The resulting programs are inhuman in outward aspect. On the other hand if a teacher writes a CAL program, it is likely to be relatively inefficient, slow running, but have some human characteristics, because the teacher knows about education from experience and formal learning. This difference is often seen most clearly in the input routines of menu-driven modelling programs [11] where informality coupled to explicit advice should be the rule instead of inhuman instructions that one identifies immediately as machine generated.

[12] Thus, to summarize, a CAL program ought to be as close as possible in its nature to the manner, characteristics and attributes of the human being that wrote it. In other words, a replicate of the teacher inside the computer.More to the point, what precise characteristics ought a "good" CAL program to have?

[13] Firstly, it ought to make maximum use of colour, sound and movement. The lesson of this was learnt long ago by

educational technologists that a performance was better than its description on paper. With cheap microcomputers like the BBC machine there is now no excuse for monochrome displays without motion or sound. The software to design such routines is available very cheaply and is easy to use. A program that actually says "Rubbish! try another input!" instead of printing it on a screen is a lot better.

Secondly, all the program should be visually and intellectually stimulating. The difference between the script of a TV programme and its actuality on the screen if you like.

Thirdly, get the user of the program involved in responding with lots of opportunity to respond in as many ways as possible. Arcade game routines can be programmed into parts of the program, as can adventure sequences like "Dungeons and Dragons", where relevant. Additionally, programs must NEVER be at a loss for an answer, and must NEVER crash, leaving the poor user in a situation that he or she cannot either understand or remedy.

Fourthly, there must be plenty of criticism, help and advice throughout the program. There should also be some form of assessment. I shall have more to say about that in a minute.

[14] This brings up the problem of getting a quart into a pint pot. To produce a CAL program of the nature I have indicated above can seem almost impossible because of the severe memory limitations of microcomputers. This is a fallacy which

derives from thinking of a CAL program (or any other program) as a single entity, entire of itself. However, if one has offline storage in the form of a disc system then there is absolutely no limit on the total size of the program at all. Where the limit applies is to a segment of the program. This accords well with the current doctrine of "Structured programming" - which is a sensible doctrine indeed since it means that programs have a logical sequence, flow and design, without a spaghetti tangle of GOTO's. Thus, one file in RAM loads the next one from disc and so on and so on. The only limitation is the available RAM for one segment of the program at a time. In other words, total freedom within the limitations of the machine in use. Such a concept is regrettably uncommon, largely I suspect because of the classical attitudes to professional programming.

Evaluation and Research

One great lack at present is information about how well good CAL induces learning in its users. From the point of view of a scientist, a new test or procedure has to be evaluated in order to show that it works, otherwise it will not be used for the innovation it is, and new knowledge will not be discovered. This procedure has not been followed very much for CAL as yet. This will be absolutely essential information if CAL is to realize its full promise as another powerful educational technology. The

problems in evaluating educational models are well enough known, and are in part responsible for the lack of effort or result in the field of educational research into the topic as yet.

[15] What needs to be done is to assess the results of the learning via CAL in cognitive terms. Not only this, but also to assess FORMATIVELY. To make the assessment part of the learning and teaching process. I said a few minutes ago that good CAL should be designed to encourage reasoning, understanding and not just inculcate facts. Unless these abilities are assessed, how are we to discover whether they are being encouraged in the first place? Such data, when acquired and analysed can be used in two ways familiar to any educational technologist. First to improve the quality and teaching potential of a CAL program, and second to influence the students formatively. The benefits of both these processes are well known. What is less well realized by most academics and teachers who are subject specialists first and educational technologists second, only because they are concerned about learning and teaching as well as their own subject, is that the results of such assessments ought to be made known through publication in the educational journals, and at educational conferences. There is not enough of this research being published. The best attitude toward this is enshrined in an axiom used by science fiction:

"What would happen if .....?"

[16] One does not know until one tries to find out.

Conclusion

We are in a strange and changing society as Alvin Toffler has said. [17] The rate of change is accelerating and nobody can predict what will happen in the next few years, though I suspect that the "Third Wave" is all around us and we don't know it. We are in the middle of the third human revolution. [18] The first was agricultural when humans started to cultivate the grasses around the campsites instead of banging animals on the head with antelope thighbones. The second followed the reformation when we began to control our environment instead of submitting to it, largely through the industrial revolution. Now, we are into the third one; perhaps one could call it "Informational"? I don't know any more than you do. As teachers and educational technologists, we are at the forefront of this explosive change, if we want to be. CAL is part of the answer but it is certainly not all of it. Computers are part of it too. But in the last analysis, all of the information, all of the technology and all of the young and not so young minds which contribute to the third revolution have to be educated, taught to think, reason and cope with it all. Go to it! [19]